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ABSTRACT

An introduction to instructional technology systems used for distance learning applications is provided, with a compilation of technical information in straightforward terms. Broadcast communications theory is discussed, and several models of communications are considered, including transport mechanics and network facilities. The most prevalent feature of the technology applications associated with distance learning is teleconferencing. The four primary modes of teleconferencing are audioconferences, audiographic teleconferences, computer conferences, and video teleconferences. Interactive distance learning technologies are categorized as narrow-band or broadband systems, both of which are described. The distinctions between analog and digital transmission are identified. Nontechnical users of distance learning systems will benefit from the rudimentary information in this paper. Five charts illustrate models and means of distance education. (Contains seven references.) (SLD)

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ED 366 313

A Technology Primer for Distance Educators

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Western Interstate Commission for Higher Education

The number of non-technical users of teleconferencing, optical storage, computer and television systems has increased dramatically in the past decade. Programming skills are no longer a prerequisite for going "on line"; multi-point teleconferencing is possible with the flip of a few switches. Even though it is no longer essential to have a detailed understanding of how instructional technologies operate in order to use them in teaching endeavors, it is increasingly clear that a basic understanding of technical system characteristics is useful knowledge for anyone teaching with technology. Technology selection strategies are more easily undertaken when users are familiar with the basic technical vocabulary used to describe these systems; understanding the operational characteristics contributes to more effective utilization.

This article has been developed to provide an introduction to the instructional technology systems used for distance learning applications. It provides a compilation of technical information presented in straightforward terms which will help educators communicate more effectively with telecommunications system designers and other technical specialists.

Communications Models

Before spending time considering the technologies themselves, it is useful to consider the dynamics of communication which the technologies encourage and promote. Many of the concerns for instructional delivery interaction have been shown to be (at least in the current literature) tied to concerns for instructional systems interactivity. Fundamental discussions of technical systems interaction comes from an early body of literature concerned with broadcast communications theory.

The Shannon mathematical theory of communication (1949) has been the most important and influential stimulus for the development of other theories and models in communications. Based upon the statistical concept of communication, a model was developed by Shannon and Weaver and presented as a schematic diagram of communication. (While initially presented as a "broadcast model" to address engineering problems, it has, over time, served as a basis for examining the process of interactive, interpersonal communication.) Schramm (1954) adapted the Shannon-Weaver Model, suggesting that this "engineering model" was not easily adapted for use with human communications problems. Among Schramm's adaptations were the addition of a feedback loop, indicating the importance of interaction as a condition for effective communication. Schramm also added a "field of experience" component to his communication model to represent the influence that experience and context have upon the interpretation of information transmitted in a communication enterprise.

Chute (1987) further adapted the Shannon-Weaver and Shannon-Schramm models by adding examples of technologies themselves. While retaining the basic form of the communication model developed by Schramm, Chute suggested that a variety of technologies could potentially serve as the "signal" in an communications enterprise. Chute can be numbered among a group of individuals working in the fields of instructional media and technology over the past thirty years

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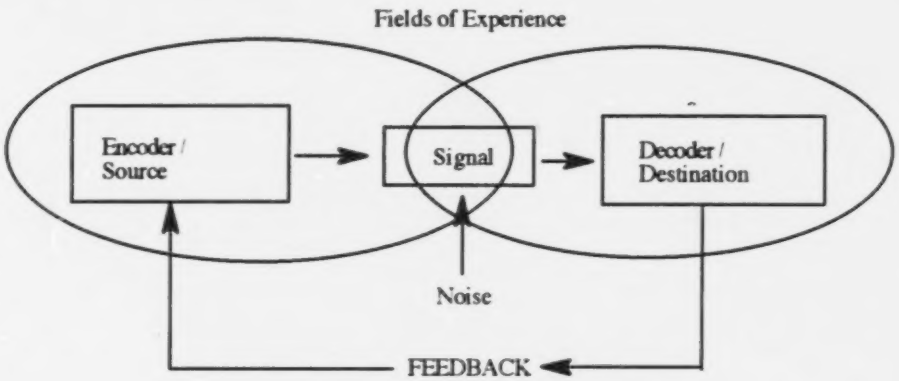
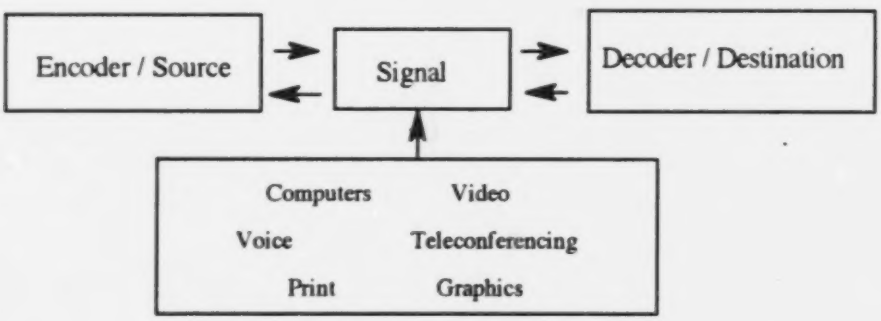
who have integrated concerns of media (defined by Heinich, Molenda and Russell, 1989) as any and all means of transmitting instructional information from teacher to student) with concerns for communications (where interactivity and feedback are seen as keys to success). Chute's efforts expanded the notion that the signal needed to be a specific variety of technology to work as an effective source in a communications effort.

In both the Shannon-Schramm Model and the Chute adaptation of that model, the *encoder*, or *source* of information is perceived as the initiator of the communications dynamic. In most instructional settings, this initiator is seen to be the teacher. The *signal* is the information, or message, to be transmitted. In instructional settings, the signal may be broadly seen as the lesson or unit of instruction, or more narrowly as the words, pictures or symbols which express the lesson or unit., The *decoder*, or *destination* is the point of reception. In instructional settings, the destination is represented by the student. The *feedback loop* permits the student / destination to function as an initiator of communication -- say, in cases where a questions may be asked of a teacher for clarification. *Noise* is any distraction which may interfere with the ability of a message to be transmitted or received, while the field of experience provides a personalized context within which the signal is interpreted.

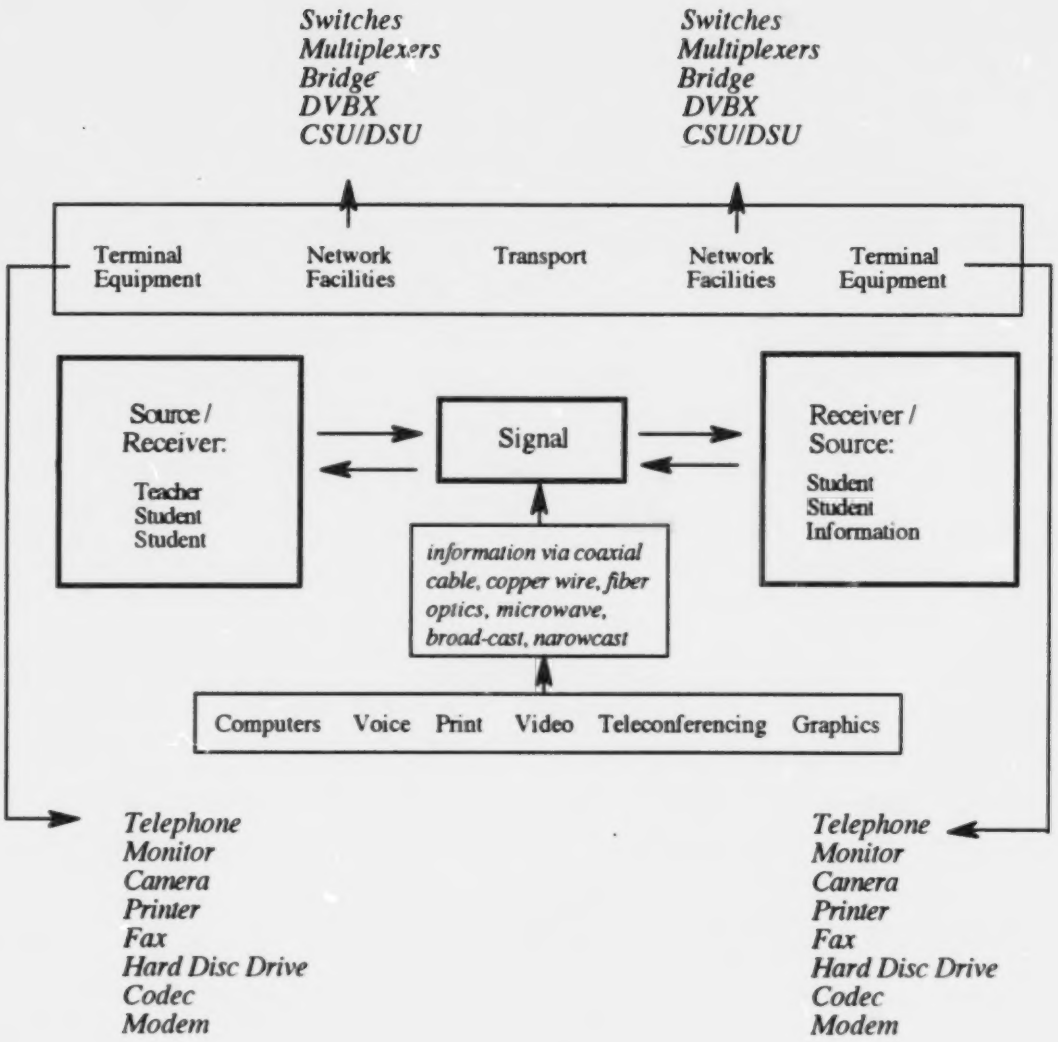


Shannon - Weaver Model of Communications, adapted by Schramm, 1954



Shannon-Weaver Model adapted by Chute, 1987

These models provide a useful foundation when interactive distance education systems of all kinds are considered. The source and destination function interchangeably; the signals can be transmitted through a variety of media.



A Telecommunications Transport Model

The communications metaphor developed by Schramm can easily be used to help distance educators conceptualize the mechanics of interactive telecommunications. Regardless of the signals being used, information needs to be transmitted interactively between the source and the destination -- between teacher and students, students and students or students and the materials to be learned. The mechanics of transmission are accommodated by means of a variety of **transport**: coaxial cable, twisted copper wire, fiber optics, satellite transmission, microwave transmission, broadcast and narrowcast television transmission represent the most common transport media currently in use. The **network facilities** provide a means of switching (where signals are situationally direct from one point to another), multiplexing (where multiple signals carried along a single transport medium are split according to applications requirements) and bridging (where signals are brought

together from point-to-point to multi-point, as in the case of a conferenced telephone call; when bridging videoconferences carried over telephone lines, this function is handled by a DVBX, a digital video bridge exchange) signals carried along the transport media, so that the electromagnetic information carried along the transport systems are directed to their intended destinations. The **terminal equipment** (which is frequently referred to as Customer Premises Equipment, or CPE) consists of the telephones, fax machines, modems, codecs, cameras, monitors and computers which transform the electromagnetic signals into the pictures, letters and figures representing the information which has been sent from the source to the receiver.

The various varieties of transport have a variety of technical characteristics which vary according to bandwidth. **Bandwidth** is a general term used to describe the amount of electromagnetic energy needed for transmission to occur. If one is dealing with analog systems, bandwidth is expressed in terms of frequency and wavelengths. In digital systems, bandwidth is more commonly expressed in terms of bits per second. Most digital systems operate in the kilobit (thousands of bit) or megabit (millions of bits) per second range. For example, early modems were rated at rates of 300 baud; this means that they could transmit 300 bits of information per second. Typical office/home fax machines currently operate at 9600 bits of information per second; this is also referred to as a 9.6 kilobit rate.

Technology Applications: Varieties of Teleconferencing

Of all of the technology applications associated with distance learning, the most prevalent applications feature teleconferencing. In teleconferencing, the exchange of voice, data and/or video signals is accommodated through a variety of technologies which include open air broadcast systems, coaxial cable systems, satellite systems as well as twisted copper and fiber optic telephony. The four primary modes of teleconferencing include:

- *Audioconferences* (which involves real-time, two way multi-point voice exchange);
- *Audiographic teleconferences* (which involves real-time, two way point-to-point, or point-to multipoint data and voice exchange);
- *Computer conferences* (which involves real-time and asynchronous point-to-point or point-to multipoint data exchange); and
- *Video teleconferences* (which involves real-time, one-way video/two way audio or two-way video and audio voice data and video exchange).

Audio teleconferencing is as available as is the telephone. An audioconference can be arranged with someone located either down the street of on the other side of the world. Telephones are ubiquitous in this country, thanks to over 60 years of national commitment to the public policy of "universal service" (U.S. Department of Commerce, 1988). Audioconferences, also referred to as conference calls, have become an increasingly common way to conduct meetings with geographically dispersed groups. Audio teleconferencing is available for the cost of telephone charges and bridging fees, where applicable. Both are inexpensive when compared to the cost of travel and the loss of employee productivity while traveling. Since the medium of information exchange involves voice only, it is useful to provide meeting participants with "advance organizers"; pre-meeting packets can be mailed to conference participants (including participant list, agenda, graphics, memos and so forth) to provide everyone with a common visual frame of reference. Since telephones are such a common and familiar means of information exchange, audioconferencing can be used effectively with a minimal amount of training. Vocal characteristics (volume, speed, inflection), vocabulary, syntax, as well as pauses and silences have a magnified

impact on the communications exchange; the greater the number of conference participants, the harder it may be to attend to vocal subtleties. Active listening must be indicated verbally by meeting participants; greetings, introductions, and farewells must be actively incorporated into the teleconference, otherwise it is not clear who is participating. Long audio conferences can be tiring, so it is useful to carefully organize AND orchestrate meetings to ensure maximum efficiency. First-time users tend to have low expectations of the effectiveness of decision-making arrived at during an audioconference. Good meeting protocols must be actively incorporated into audioconferences meetings.

Audiographic teleconferencing enables visual enhancement of audio teleconferences through a variety of ways: facsimile, interactive electromagnetic drawing devices, computers and slow-scan ("freeze frame") television systems. It makes use of very narrow bandwidth transmission systems, which means that audiographic teleconferences can be carried on regular voice grade telephone lines or via VSAT (very small aperature terminal) satellite systems. This results in low transmission costs when compared to voice / data / video systems. It is possible to create a greater sense of shared space than with audio teleconferencing by providing visual cues, creating visual awareness of the participants and the room ambience at other sites. Audiographic teleconferencing allows graphic information to be transmitted in real time, concurrently with voice transmission, which makes it especially useful for situations where pictures, graphics, diagrams, plans, schematic drawings and other visual materials are an important part of the information exchange dynamic. This means, for example, that audiographic teleconferencing is often effective at the working level when engineers need to see designs, doctors need to see X-rays and repair technicians need to see broken equipment at remote sites. Graphics must be carefully prepared according to the demands and constraints of the medium. Electronic "white boards" and fax machines can be used in an audiographic teleconference to send data to distant sites simultaneously with voice signals over the telephone or audiconferencing systems, while some varieties of audiographic teleconferencing systems integrate voice and data signals being carried via computer.

Computer conferences involve the point-to-point or point-to-multipoint exchange of data, either in real time computer conferences or in asynchronous modes of exchange such as electronic mail, bulletin boards and file transfer. Information can be sent electronically and received at remote sites instantaneously via telephone lines and modems; messages can be sent and received at any time. There is access to the system, the data base, and other participants' input from any location there is a telephone and a modem. The teleconference is independent of time zones and personal schedules, which makes it a particularly useful way of staying abreast of ongoing discussions without having to interrupt one's other responsibilities. The message is sent electronically, and is stored until the recipient has time to read it. Because files are electronic, paperwork is reduced, files cannot be misplaced or lost, and information is delivered independent of weather, holidays and so forth. In computer conferencing there is a complete record of all messages and interactions. These can be access and printed out whenever needed.

The keyboard is the only outlet for expression making it especially challenging to communicate nuances and subtleties of messages. Communication protocols have emerged among regular users of electronic mail and bulletin board systems, making it easier to accent important information (for example, the use of presenting some information in all capital letters means that it REALLY stands out; other symbols, when viewed from the side, are used to express happiness [:)] or sadness [: (]. Participants have equal access to "the floor", and have the opportunity to participate without regard to their relative organizational status. Participant anonymity is more possible in this medium than in other teleconferencing formats.

Video teleconferencing is best in those situations dealing with complex tangible objects and those requiring visual feedback for an idea. It allows conference participants to see each other's reactions to ideas, and can impart a sense of one-to-one participation. Video conferences involve the transmission of voice, data and video signals. They include both one-way video, two-way audio

transmission, where the visual information can be carried by means of broadcast, ITFS or satellite and the voice signal carried by telephone, as well as two-way audio and video where duplexed signals are carried by means of fiber optics, compressed video or two simultaneous uplink / downlink arrangements.

Satellite based transmission can provide a wide field of signal distribution; anyone with a downlink dish appropriate for the signal being tranmitted within the footprint of a particular satellite (e.g. Ku band or C-band) has the potential of participating in that conference. This particular variety of video conferencing provides high exposure to a new idea, new leaders, new products, new information by virtue of its "mass media" orientation.They most generally consist of one-way video transmission of information from an uplink location to a large number of downlink sites; two way audio loops are accommodated through telephone hook-ups. Information carried via satellite based video conferences can either be open to anyone able to receive the satellite's signal, or the signals can be encrypted, or "scrambled", so that only those subscribers with descrambling information can decipher the transmitted signals.

Two way video/audio teleconference generally make use of telephony-based systems carried via fiber optics or twisted pair copper telephone lines. Voice, video and data signal can be carried via a signal transmission channel; compression technologies have greatly reduced the amount of bandwidth needed to send video signals over any transmission medium, whether satellite, broadcast, cable or telephony.

High capital investment is necessary in order for video teleconference to operate effectively. It can be cost-justifiable for large groups in multiple locations. In order to make certain that all of the various system components work effectively in combination with one another, great deal of advance planning and preparation is required. Room and transmission requirements will vary, but tend toward the complex. There is not the same flexibility of site switching as there is in other teleconferencing formats. There is not necessarily the same degree of anonymity with two-way video, two-way audio teleconferences as with other teleconference formats, although large-scale, one-way video, two-way audio teleconferences can potentially involve thousands of participants.

Bandwidth Requirements

Interactive distance learning technologies tend to be categoried as either *narrow-band* systems or *broadband* systems. This reference to bandwidth refers to the amount of electromagnetic energy which is required for successful transmission to occur. Transmitting a large amount of information in a small amount of time requires the use of a broadband system, whereas large amounts of bandwidth transmitted over longer periods of time reduce transmission requirements. In general, narrowband systems refer to those technologies which require up to or equal to 1.5 Mbps of information. This is refered to as DS1, or T-1. The technologies falling into this category include telephones, facsimiles, modems, electronic white boards, audiographic teletraining units, freeze -frame video and compressed video systems. In general, narrowband systems employ telephone based systems for their carriage. Broadband carriage is generally greater than T1; for compressed video system, DS3 or T3 transmission rates carry information at a rate of 45Mbps, while full motion video requires approximately 92 Mbps of bandwidth. Broadband systems include full motion video systems such as cable, broadcast and satellite TV; broadband systems also include high speed data systems.

Analog and Digital Transmission

Until recently, electromagnetic information has been transmitted via analog waveforms, traveling as continuous waves of electromagnetic energy. Analog waveforms are expressed in terms of cycles per second, or *Hertz*. When these waves are stored for transmission there is inevitably some loss of

waveform information. Recent technological developments have led to the use of digital transmission. Digital signals are expressed in terms of bits per second. 1 baud equals 1 bit per second. In digital systems, the signals are expressed as "blinking lights" -- either the signal is "off" or it is "on". This means that digital signal information can be stored without any loss of quality. A chart comparing analog and digital tranmission characteristics has been provided on the following page.

Equipment Descriptions

Descriptions of commonly used interactive distance learning technologies - facsimiles, modems, codecs, broadcast and narrowcast television, satellite systems and fiber optics -- have been provided in the following pages.

Summary

Many distance educators are finding themselves making decisions about complex instructional delivery systems without having a clear conceptual understanding of the system components or their operational characteristics. The information contained herein is intended to give non-technical users of distance learning systems with rudimentary information about the instructional delivery system components they are likely to encounter in their project development endeavors.

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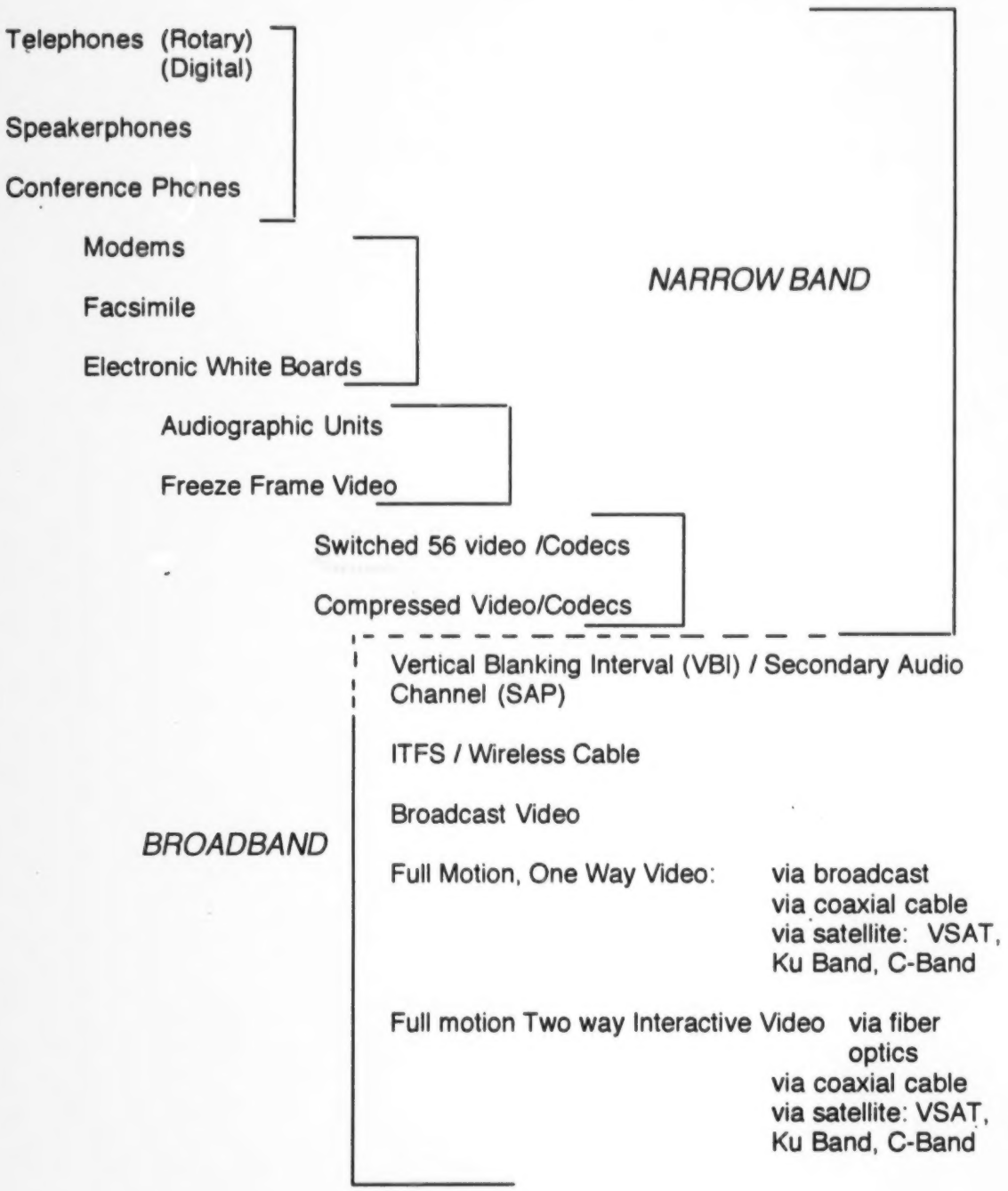
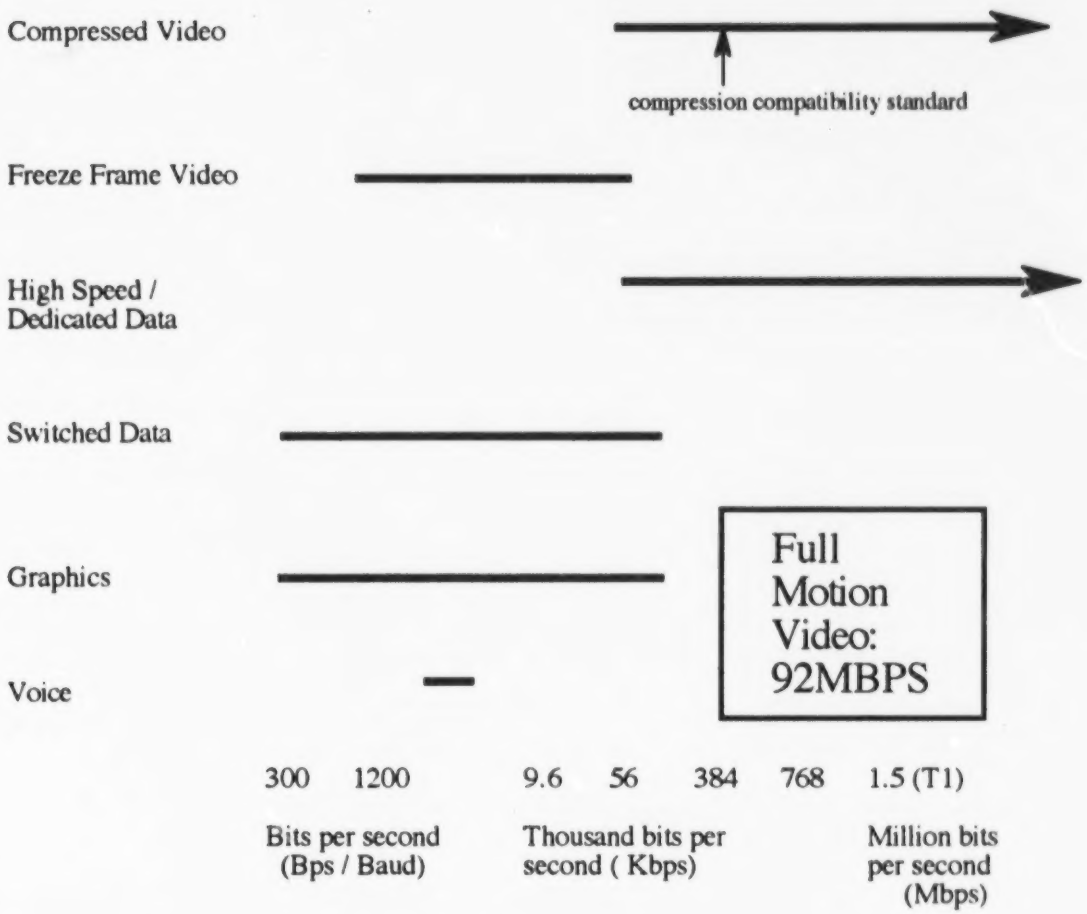
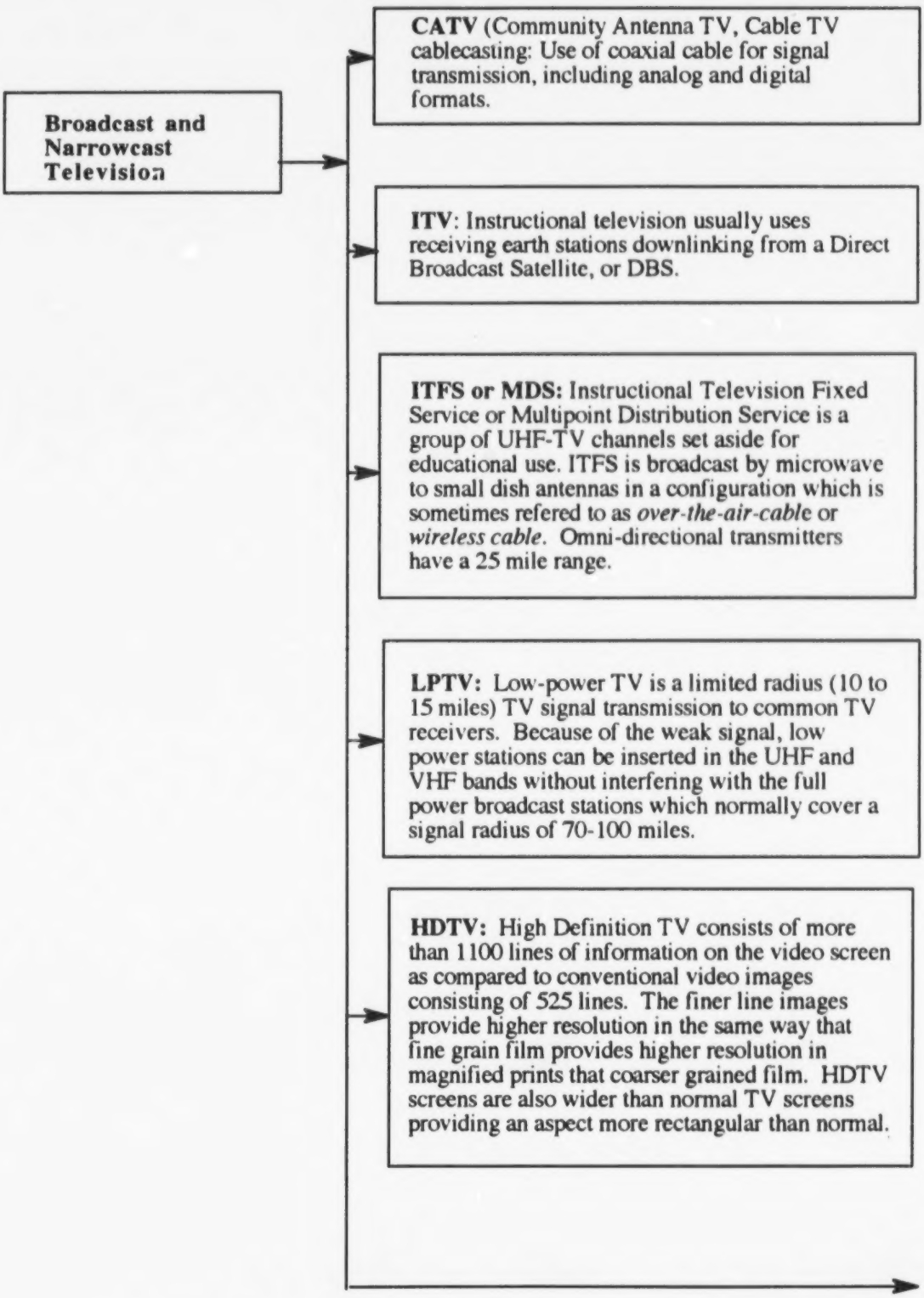
Narrow and Broadband Technologies Commonly Used in Distance Education

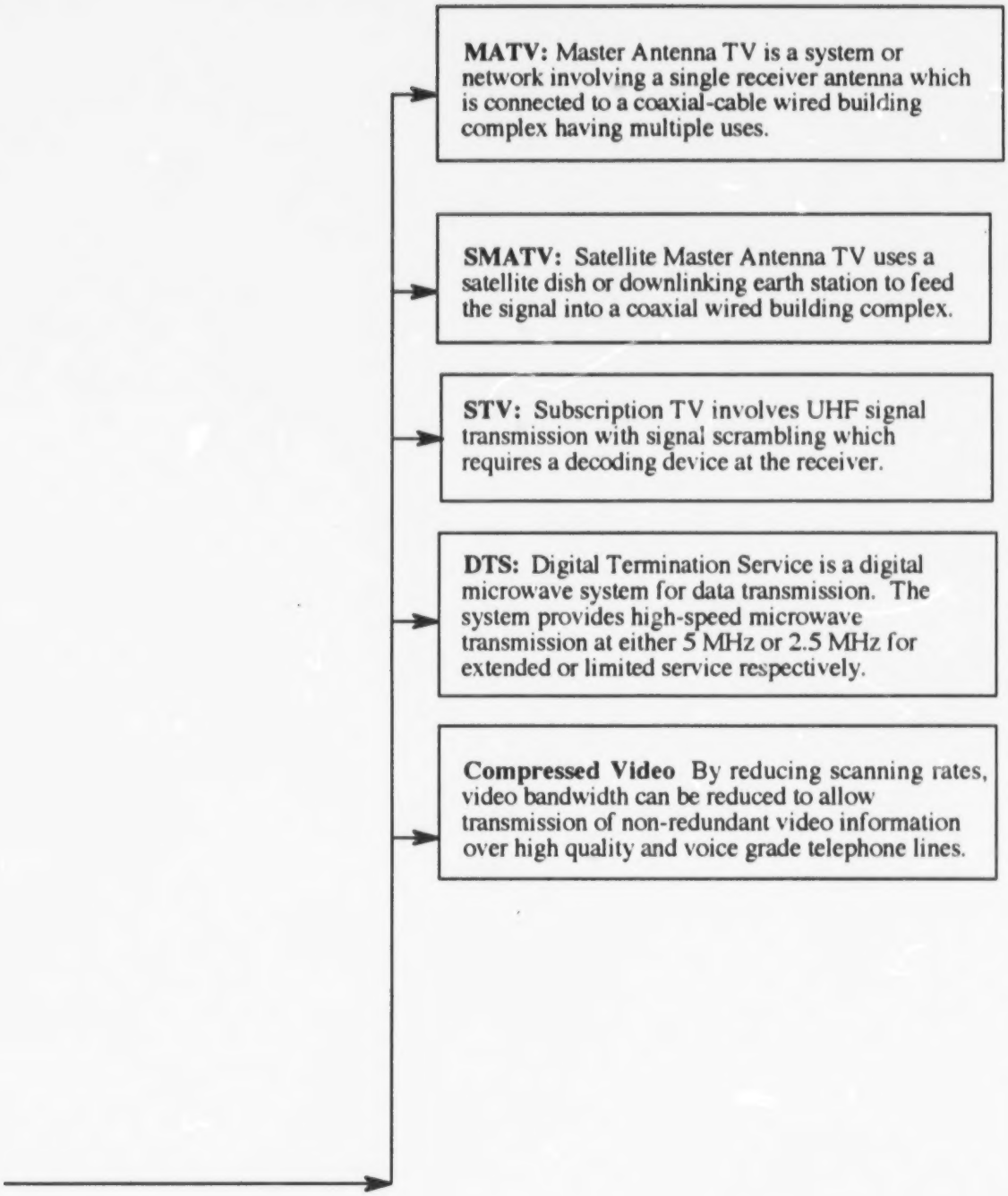


Bandwidth Requirements for Common Teleconferencing Systems



Telephone technology provides the carriage needed to transmit the signals noted on this chart. These delivery systems make use of DS0 (144 kbps) and DS1(1.5 Mbps) transmission rates. Twisted copper wire is generally used for transmission purposes, which are currently electromagnetic in nature. As carriage evolves toward optical systems, it will be possible to carry these signals (or their equivalent) via fiber optic cable.


Broadcast and Narrowcast Television
CATV (Community Antenna TV, Cable TV cablecasting: Use of coaxial cable for signal transmission, including analog and digital formats.
ITV: Instructional television usually uses receiving earth stations downlinking from a Direct Broadcast Satellite, or DBS.
ITFS or MDS: Instructional Television Fixed Service or Multipoint Distribution Service is a group of UHF-TV channels set aside for educational use. ITFS is broadcast by microwave to small dish antennas in a configuration which is sometimes refered to as over-the-air-cable or wireless cable. Omni-directional transmitters have a 25 mile range.
LPTV: Low-power TV is a limited radius (10 to 15 miles) TV signal transmission to common TV receivers. Because of the weak signal, low power stations can be inserted in the UHF and VHF bands without interfering with the full power broadcast stations which normally cover a signal radius of 70-100 miles.
HDTV: High Definition TV consists of more than 1100 lines of information on the video screen as compared to conventional video images consisting of 525 lines. The finer line images provide higher resolution in the same way that fine grain film provides higher resolution in magnified prints that coarser grained film. HDTV screens are also wider than normal TV screens providing an aspect more rectangular than normal.


MATV: Master Antenna TV is a system or network involving a single receiver antenna which is connected to a coaxial-cable wired building complex having multiple uses.
SMATV: Satellite Master Antenna TV uses a satellite dish or downlinking earth station to feed the signal into a coaxial wired building complex.
STV: Subscription TV involves UHF signal transmission with signal scrambling which requires a decoding device at the receiver.
DTS: Digital Termination Service is a digital microwave system for data transmission. The system provides high-speed microwave transmission at either 5 MHz or 2.5 MHz for extended or limited service respectively.
Compressed Video By reducing scanning rates, video bandwidth can be reduced to allow transmission of non-redundant video information over high quality and voice grade telephone lines.

Satellite Technology

A *satellite* is both a receiver and a transmitter. A ground station sending a signal to a satellite is an uplink. The signal frequency is boosted and then retransmitted back to an earth station on the ground. This retransmission process is referred to as downlinking, and uses TVRO (television receive only) dishes for reception.

Features of Satellites include:

- A single transmitting earth station can provide a signal which can be downlinked by hundreds of other receiving earth stations, or to earth stations which serve as the "head end" of a cable distribution network.
- Most satellites have 24 transponders. Each one is able to handle a single TV channel or about 1,000 telephone calls at once.
- Compression technologies will continue to dramatically increase the availability and number of channels per transponder.
- Satellites are positioned in an orbit near the equator. This allows them to move synchonously with the earth, staying in the same position with their earth stations below. This orbital position is known as a "geosynchronous orbit". The narrow band 22,300 miles over the equator where most satellites are positioned is known as the *Clarke Belt*.
- Most satellites in orbit tranmit in the C-Band (4-6 GHz) or the Ku Band (10-15 GHz.).
- Because of the orbital locations of the satellites, the receiving area will be different for each satellite's relative location. This downlinking capacity over an area of the earth is known as the "footprint" of the satellite. Earth stations outside of the "footprint" of a particular satellite will not be able to receive its signal.

Fiber Optics

Fiber optics are the most recent innovation in the development of communications transmission media. Information can be sent in previously unimaginable amounts through hair-thin glass filaments over extended distances at the speed of light.

Features of Fiber Optics Include:

- Information transmitted by semiconductor lasers that blink computer code via lasers.
- Pulses at 500 million times per second
- Can carry 8000 voice conversations on a single fiber pair.
- Can provide 1 second transmission of 100 copies of the Wall Street Journal (a traditional copier would take 20 hours to perform the same task.)
- Increases bandwidth of transmissions
- Well suited to video transmissions
- Needs less amplification boost
- Is distortion free
- Is not subject to electromagnetic interference
- Has demonstrated speeds from 42 to 160 MBPS

Fiber Optic Applications Include:

- Local Area Networks
- Main telephone trunk connections
- serves as the base technology for joint communication channels
- ISDN - integrated services digital network
- Long distance communications
- Secure transmissions of voice, video and data